AD NUMBER

103 991

CLASSIFICATION CHANGES

TO

UNCLASSIFIED

FROM

CONFIDENTIAL

Code 23

AUTHORITY

Original Classifier; via Doc Mrkngs

AD NUMBER

103 991

LIMITATION CHANGES

TO: Approved for Public Release...

CODE: 1

FROM: DoD Agencies & their Contractors

CODE: 2

AUTHORITY

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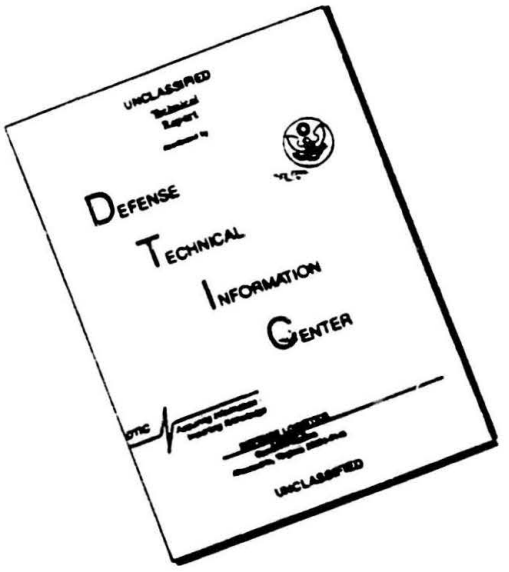

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THE HARTWELL PROJECT

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Presented at the Sixth Undersea Symposium

9-10 May 1951
Washington, D. C.

SERIAL NRC:CUW:0134 COPY NO. 27

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I feel like a man giving an imitation of a man pretending to read a speech. When Dr. Zacharias asked me yesterday to deliver this he told me he had it all written out. Later he said, "Of course you'll have to fill in here and there."

The HARTWELL Project was an attempt to bring to the problems of undersea warfare the combined experience of a number of people who played more or less prominent roles in World War II in the field of atomic warfare, radar, sonar, rockets, fire control, proximity fuses, and so forth. Among others, the group included Alvarez of California, Berkner, Roberts, and Tuve of the Carnegie Institution of Washington; Eckart of Scripps Oceanographic Institution, Friis, Kock, and Potter of Bell Laboratories; Admiral Cochrane, Getting, Hubbard, and Wiesner of MIT; Lauritsen of the California Institute of Technology, Nordsieck of Illinois, Purcell of Harvard, Joyce of the Bureau of Aeronautics, and others; and in particular we were fortunate in having Captain Groverman, who was in charge of the Undersea Warfare Branch of the Office of Naval Research at that time.

We encountered the most encouraging and helpful group of officers and civilians in the Navy that one can imagine. If the project was unsuccessful, it was in no way the fault of the Navy; the blame must rest with the group itself. We were particularly impressed with the free interchange of ideas, even in our earliest discussions with Navy groups, and indeed we believe our early discussions had some immediate effect on the Navy's point of view. We were given the widest latitude possible in examining every phase of the security of overseas transport and harbor defense; we feel very strongly that in a short-term project such as HARTWELL this broad permissive, but not mandatory, scope is essential.

For instance, when the project was conceived it was thought of as a project to look into problems of submarine detection. We soon found in attempting to recruit personnel that most persons' initial reaction went something like this: "Well, I don't know that I can invent anything that will help detect submarines in three months' time, but maybe I can help if I know a little more about the general problem." Before we first met as a group our directive had changed to a study of all problems connected with the transport of materiel overseas in time of war. The project started June 5, 1950 and ended September 30, 1950 with the delivery of 700 copies of our report of about 600 pages. It is at least twice as long as it should be, but we didn't have time to write it very well since we thought early delivery more essential. Since there are so many copies of this report, I am sure you have all seen it and I shall not try to give a resume but rather discuss some of the highlights of the project.

I think all of us started this job with the distinct feeling that this country was very much like a man with an inoperable cancer; that he might linger a while but he was really done. We changed this

opinion before finishing, but the change was gradual. I think we discovered that underwater sound and radar, which we thought were dead, were not dead at all but were very lively things. What they needed was a lot of push, effort and emphasis, and they could be made really effective. We thought helicopter dunked sonar, when we first heard about it, was the straw the dying man grasped. When we got through we had a great deal of respect for the sonar and helicopters.

A preponderance of the members of the group had something to do with radar during World War II and all of us were very discouraged, initially, about the effectiveness of radar in detecting submarines. With about one hundred thousand dollars worth of electronic gear, an aircraft can detect a snorkel at 10 to 15 miles range. On the other hand, with about five dollars worth of listening equipment, the submarine can hear the radar at horizon ranges for any imaginable height of aircraft. Hence the submarine starts with an overwhelming advantage unless we can take advantage of the limitations of the listening receiver. There are two conditions under which a receiver is of little or no use: (1) when it never hears a radar; and (2) when it always hears a radar or radars. We can bring about the first condition if we shut off our electronic gear, but in this case we might as well not carry it. We can accomplish the second condition by constant radar patrolling; the very long range of the receiver is to our advantage. If the submarine always hears radar signals it must either remain submerged, and hence seriously limit its own operation, or else ignore the radar signals. In either event we have made effective use of our radar, and if the submarine chooses to ignore our radar signals, we have really put the radar back in business. This principle of "Radar Flooding" is very important to the radar, countermeasure, counter-countermeasure game.

In the field of sonar we found that the higher frequency field had been very well exploited, but that ranges of 2,000-4,000 yards were about maximum for echo-ranging, partly because of the high attenuation. It was apparent that the low frequency end of the sound spectrum, 100-1,000 cycles, held much prospect for extremely long ranges, especially for passive sonar. The recent work of Kock's group at BTL bears this out as Admiral Solberg has mentioned. We feel that further exploitation of the low frequencies in sonar is very much in order, and will lead to a vast increase in our submarine detection capabilities.

In addition to improving long-range detection by sonar and radar, it is necessary to improve identification gear. At present the only positive form of identification of submarines, outside of a torpedoed surface craft, is by magnetic means. We must not damn present MAD gear because its range is too short for use as search equipment, but rather we must exploit such gear for its identification ability. Recent work indicates that novel methods hold some hope in this regard.

Furthermore, the whole problem of presenting radar-sonar data to the operators was one that was neglected very much during World War II. It was at least neglected by the radar people, and we know that

operator factors of about 1% are common. We feel that here is a very fruitful field for investigation, which can make a tremendous improvement in the use of both radar and sonar.

I believe that most people who have studied ASW will be in general agreement with the above conclusions. Turning now to the question of weapons, I am sure we will find a more controversial topic. The cost of detecting, localizing, and identifying a submarine is so tremendous that it is necessary to have weapons of almost certain lethality or else the economics of the situation will make our position untenable. The present surface craft armed with depth charges, hedgehog, and Weapon A is like a short-armed boy trying to box a long-armed man when in combat with a submarine equipped with homing and pattern running torpedoes. Even if the destroyer carries modern torpedoes for retaliation, it is still at a serious disadvantage in detection, since surface craft are necessarily noisy and submarines are not.

Two courses are open to us, namely, the use of very long range homing torpedoes which spend most of their time of flight in the air where viscous drag is much less than in the water, and secondly the use of atomic depth charges. The use of the first weapon depends on the improvement of present long range detection schemes, while the use of the atomic depth charge depends on the improvement of positive identification measures. But to get improvement in our weapons we must assume that improvements in long range detection and in positive identification will come along. Certainly there is now a good deal of evidence to support this assumption.

Economic arguments against the use of atomic depth charges are not valid. I cannot speak with authority, but I can guess that atomic bombs cost less than submarines, and cost a great deal less than the amount of ships and cargo that one unopposed submarine can destroy on a single cruise. Recent model tests by the British indicate that a deep burst of 22,000 tons of TNT is lethal against submerged submarines at one mile, and probably at ranges up to two miles.

When our project started we were told that for several years after the beginning of a new conflict, our overseas transport would be carried principally by Liberty ships in 8-knot convoys. Such convoys, opposed by submarines carrying homing and pattern running torpedoes of long range, and by aircraft and submarines carrying atomic weapons, looked to us like dead ducks indeed. We believe that fast ships, say 20-knot, carrying stingers, whether in convoy or not, would be a much more effective means of carrying precious and vital cargo. Economic arguments against fast ships must counter the fact that the cargo is so valuable in time of war that even a small decrease in vulnerability of the ships is generally worth the cost. We are very happy to note that the Maritime Administration has undertaken a sizable program in the procurement of new fast merchant vessels.

Along with the improvement of ships for carrying the cargo, we stress that port facilities both at home and abroad must be extended and modernized if our overseas transport is to reach peak efficiency.

As regards harbor defense and mine countermeasures, I must confess that the HARTWELL Project did not give these very important subjects the attention that they deserve. However, we did reach some general conclusions which may bear mention. In the game of mine, mine countermeasure, counter-countermeasure, the odds are all in favor of the mine man since he can call the tune. Against modern mines the only effective sweeper is the ship itself, but what is more important, it is not difficult to show that the economics of locating and destroying a mine are more favorable by a factor of 10 to 100 than the economics of mine sweeping, even if the sweeper is itself not lost. Hence we feel that every possible effort should be made now in the direction of locating and destroying mines. Since present harbor bottoms are now covered with litter not too different from mines in appearance, it is important that harbor surveys and perhaps even harbor cleaning begin at once so that mines, when they arrive, can be readily identified as such.

In conclusion I should like to mention again the three points Admiral Akers made so strongly; namely, the need for better mine countermeasures, the need for longer range detection equipment against submarines, and the need for more precise identification gear against submarines. I heartily agree with these three points, but to them I should like to add another and to stress it even more strongly. That is, I feel we must increase our kill potential once a submarine has been detected, localized, and identified. The task leading up to identification is so costly, so arduous, and so dull that we must not risk missing at the critical moment.

Earlier I said that when we started Project HARTWELL we regarded the country as one regards a man with an inoperable cancer; doomed. When we finished, we felt that our earlier diagnosis had been wrong. Actually, the patient had rickets, halitosis, and a bad hangover, but nothing that occupational therapy could not cure.

Finally, let me remark that last year at this conference there was a great deal of talk about the threat of the true submersible. The project also thought that the threat of the true submersible was a dire one and one requiring much effort to counter. However, we agreed that if we could effectively counter the guppy-snorkel class of submarine, we would have gone more than half way in countering the true submersible.

ADM AKERS: Thank you very much, Dr. Hill, that was a most enjoyable talk. I am going to take my prerogative of being up here and ask the first question of Dr. Hill. Meantime, I will ask that any other queries be prepared. This is not really a question, it is more a statement of

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air weapons. Our sending the weapon through the air without having to take up the resistance from the water--our feeling is that that is all fine but at the present time we have neither the detection nor the identification to warn him. The only way now to find out if we have a sub is to get on top of the sub and tell some ship to shoot up where we are. So as long as we can accomplish the detection and identification--do you want to say anything on that, Albert?

DR. HILL: I think only that the development of the weapons and the detection equipment have to go together. I think your point well taken.

ADM AKERS: The first question I have is by Nelson Blackman: "What sort of frequencies are used in low frequency sonar?"

DR. HILL: Below a thousand cycles but preferably in the range of 100-200 cycles.

ADM AKERS: I have another question which nobody signed. It says that it is for the consideration of the Navy Department speaker before this group. "What is the status of implementation of the HARTWELL Project?" I think I can assure you that the HARTWELL Project was receiving the attention that it should be receiving and that it is being implemented. About the only thing there is a little lack of agreement on is the question of going into such an expensive program when actually it looks fairly distant. At present the effort is to push the short-term program.

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